

CLAIMS

What is claimed is:

- 1 1. A mask comprising:
 - 2 a mask substrate, and
 - 3 at least one annular equal line space phase shifting pattern on said mask substrate to
 - 4 produce an opaque region on a semiconductor substrate.
- 1 2. The mask of claim 1, wherein said pattern comprises an annular ring and a central portion.
- 1 3. The mask of claim 2, wherein said annular ring has a phase shift of approximately 180 degrees from said mask substrate and said central portion.
- 1 4. The mask of claim 1, wherein said pattern comprises a plurality of annular rings and a central portion.
- 1 5. The mask of claim 4, wherein an outermost annular ring has a phase shift of approximately 180 degrees from said mask substrate and an adjacent inner annular ring, each inner annular ring having a phase shift of approximately 180 degrees from its outer adjacent annular ring, and said central portion having a phase shift of approximately 180 degrees from an innermost ring.
- 1 6. The mask of claim 1, wherein said mask substrate comprises quartz.
- 1 7. The mask of claim 1, wherein said pattern is substantially transparent to an incident radiation for photomasking.
- 3 8. The mask of claim 1, where a mask pitch of said pattern is smaller than two times of a corresponding critical dimension pitch on said semiconductor substrate.

- 1 9. A method of manufacturing a mask, comprising:
 - 2 providing a mask substrate;
 - 3 forming a layer of resist material over said mask substrate;
 - 4 patterning at least one annular equal line space phase shifting pattern on said resist layer;
 - 5 patterning said pattern onto said mask substrate;
 - 6 removing a remaining portion of said resist layer.
- 7 10. A method of manufacturing a mask, comprising:
 - 8 providing a mask substrate;
 - 9 forming a layer of conductive material over said mask substrate;
 - 10 forming a layer of resist material over said conductive layer;
 - 11 patterning at least one annular equal line space phase shifting pattern on said resist layer;
 - 12 patterning said pattern onto said conductive layer;
 - 13 removing a remaining portion of said resist layer;
 - 14 patterning said pattern onto said mask substrate; and
 - 15 removing a remaining portion of said conductive layer.
- 1 11. The method of claim 10, wherein said mask substrate comprises quartz.
- 1 12. The method of claim 10, wherein said layer of conductive material comprises chrome.
- 1 13. The method of claim 10, wherein said pattern comprises an annular ring and a central portion.
- 1 14. The method of claim 10, wherein said pattern comprises a plurality of annular rings and a central portion
- 1 15. The method of claim 10, wherein said pattern is formed on said mask substrate by etching said mask substrate.

1 16. The method of claim 10, wherein said pattern is formed on said mask substrate by
2 disposing phase shifting material on said mask substrate.

1 17. A method of transferring a pattern onto a semiconductor substrate, comprising:
2 illuminating a mask comprising at least one annular equal line space phase shifting
3 pattern on said mask to produce an opaque region on said semiconductor substrate.

1 18. The method of claim 17, wherein off-axis illumination is used for illuminating said mask.

1 19. The method of claim 18, wherein off-axis illumination can be a single point, dipole,
2 quadrupole, or annular type off-axis illumination.

1 20. The method of claim 18 wherein deep ultra radiation is used as a radiation resource to
2 illuminate said mask.

1 21. The method of claim 18 wherein said semiconductor substrate comprises silicon.

1 22. A semiconductor wafer manufactured by the method of claim 18.